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From: General Aviation Human Factors Program Manager, ATO-P Human Factors R&D
To: General Aviation TCRG

Subj: GENERAL AVIATION HUMAN FACTORS FIRST QUARTER '05 REPORT

Ref: General aviation human factors execution plans (http://www.hf.faa.gov/gafunded.htm)

1) Each project is listed below.

a) Human Error and General Aviation Accidents: A Comprehensive, Fine-Grained Analysis using HFACS

Although the collaborative agreement between the University of Illinois (Dr. Douglas Wiegmann) and the Civil Aerospace Medical Institute (Dr. Scott Shappell) associated with this requirement has been completed, both parties have agreed to extend the agreement *at no cost to the Federal Government* to include several important initiatives on the FAA's agenda. Specifically, CAMI and the University of Illinois will complete a number of HFACS analyses and provide reports to sponsors on the following issues (many of which are part of the AVR business plan and dashboard):

- *Complete data processing and prepare report describing the analysis of commercial aviation accidents (1990-2000) using the Human Factors Analysis and Classification System (HFACS).* This project can be found on page 10 of the AVR Business Plan as part of Flight Plan Performance Target: Airline Fatal Accident Rate; Strategic Initiative: Human Factors; Strategic Activity: Commercial Accidents Analysis.

  Progress to date*:* All human factors associated with commercial aviation accidents since 1990 have been classified by CAMI's seven pilot subject matter experts using HFACS. The data will be submitted to a human factors quality assurance (HF QA) process beginning in January and completing during the 2nd quarter of FY05. Once the HF QA process is complete the human factors analysis of commercial aviation accidents will commence.

- *Conduct a detailed human factors comparison of general aviation accidents occurring in Alaska with those occurring in the rest of the U.S.* This project can be found on page 11 of the AVR Business Plan as part of Flight Plan Performance Target: GA Fatal Accidents; Strategic Initiative: Human Factors; Strategic Activity: Human Factors Comparisons and Analysis.

Progress to date: Preliminary results from the 1990-2000 Alaska GA accident analysis using HFACS were presented at the GA Program Review in October. Since then, the 2001 GA data has been received and is now undergoing the HF QA process. Delivery of the 2002-present data is expected in the January-February time frame. Once the data has undergone the HF QA process a final analysis will be conducted and a report delivered to the sponsor.

- *Conduct a human factors analysis of accidents involving emergency medical services (EMS) aircraft.* This project can be found on page 11 of the AVR Business Plan as part of Flight Plan Performance Target: GA Fatal Accidents; Strategic Initiative: Human Factors; Strategic Activity: Human Factors Comparisons and Analysis.

  Progress to date: The analysis of EMS data will begin at the conclusion of the HF QA of both GA and commercial data. However, in light of the recent upturn in EMS accidents this initiative has taken top priority among others within this line of work. Consequently, we are currently in the process of preparing a "preliminary" report for AVR before the entire HF QA process is complete. Given the small number of EMS accidents relative to the larger database we will be able to HF QA these accidents first and will issue a report earlier than anticipated. Of historical note, the HF QA process effects less than 5% of over 40,000 cases coded by our pilot subject matter experts.

- *Analysis of Air Tour, Gulf of Mexico, and Rotorcraft operations.* Although not on the AVR Business Plan or dashboard per se, additional analyses have been requested as "pop-up" items by a variety of sponsors in the field (e.g., FAA Air Tour NRS, AFS-840). These include an analysis of Air Tour accidents, an analysis of off-shore, Gulf of Mexico operations (primarily involving transport to and from offshore oil rigs along the Gulf Coast, and an overall analysis of rotorcraft accidents relative to their fixed-wing counterparts. Other analyses that have been mentioned but are not currently on the FY05 calendar include HFACS analyses of homebuilt, agricultural, and glider operations. CAMI and University of Illinois will continue to work these issues over FY05 and will report on these initiatives in quarterly reports.

The original requirement has been completed and a final report has been submitted for approval. The requirement has been extended to include the analyses above. All indications are that the additional items are on track.

b) Credit for Instrument Rating in a Flight Training Device or Personal Computer: Phase III: Transfer of Training Effectiveness of a Flight Training Device (FTD).

Thirteen students (the final subjects involved in this collaborative agreement between the University of Illinois and the Civil Aerospace Medical Institute) were enrolled in AVI 140 (Advanced Instruments) for the fall semester. Eleven students completed the course and took the final check ride. Two students were scheduled for a remedial course next semester. Of the eleven students that took the final check ride, nine passed on their initial attempt. Of the remaining two, one passed on the second check ride. The other student failed the second check ride and is presently scheduled for a 3rd check ride in January, 2005. At that time, the data collection phase will be completed and the data analysis phase will begin.

The overall results to date for for the project including the 10 fall semester students who have already completed the final check ride are shown in Table 1. The table will be revised when the other student has completed the 3rd check ride and the final report will be written.

Table 1. Flight Lesson 60 Statistics

	Airplane Only	***PCATD***	***Frasca Trainer***			
Hours in training device	*(NA)*	*5*	*5*	*10*	*15*	*20*
Number of Students reaching check ride (lesson 60)	18	18	20	16	15	19
% Students taking 1st check ride who passed *(numbers of students)*	44.4 *(8 of 18)*	55.6 *(10 of 18)*	45.0 *(9 of 20)*	43.8 *(7 of 16)*	40.0 *(6 of 15)*	57.9 *(11 of 19)*
% Students requiring 2nd check ride who passed *(numbers of students)*	100.0 *(10 of 10)*	75.0 *(6 of 8)*	88.9 *(8 of 9)*	88.9 *(8 of 9)*	100.0 *(9 of 9)*	62.5 *(5 of 8)*
Number of Students requiring 3rd check ride who passed	0	1	1	1	0	1*
Students failing 1st or 2nd check ride and not receiving 2nd or 3rd	0	1	2	0	0	1
Mean Total Dual hours (in airplane) to Completion for those passing the check ride on 1st, 2nd, or 3rd attempt *(& sample size)*	26.38 *(n=18)*	25.78 *(n=17)*	24.73 *(n=18)*	23.60 *(n=16)*	21.93 *(n=15)*	20.11 *(n=17)*
Variance in Total Dual hours to Completion	16.55	6.03	7.77	8.80	10.20	9.94
Students recommended for remedial training	2	3	4	3	5	3

The mean total dual hours in the airplane to completion are depicted in Figure 1 below. What is evident is that the only notable advantage over airplane training alone (the control condition) is seen when 10, 15, or 20 hours of training take place in the Frasca. Note that there is a large degree of variability associated with these data (see table 1) which will likely affect significance testing.

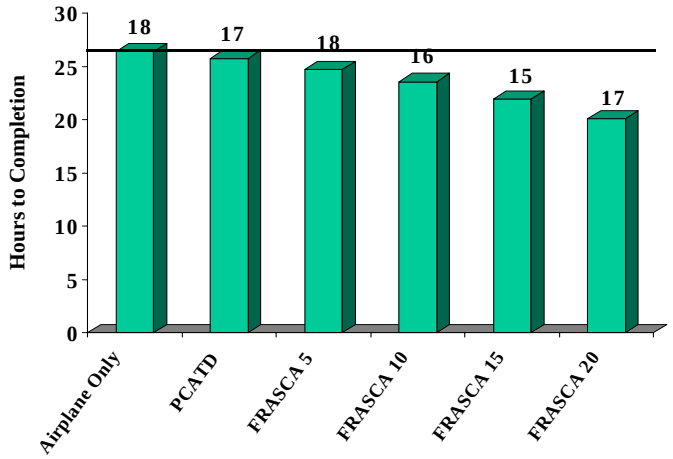

Figure 1. Mean hours to completion for those passing the 1st, 2nd, or 3rd check ride.

All available information indicates that this project is on track.

c) Visibility in the Aviation Environment

Completed and distributed training device,"visual aid to detection" - available at http://www.hf.faa.gov/docs/508/docs/visible_card.pdf This device was made available over the FAA website. The availability was announced via e-mail to over 113,653 addresses. The announcement was also picked up by several aviation groups (e.g. EAA) and distributed to their memberships. The feedback from this simple aid was overwhelmingly positive and unedited comments are attached.

Sample of comments of the visual aid to detection card from the public

> *1) That is most interesting and a little scary. No wonder I've missed small planes at a mile.*
>
> *2) Very helpful. I've always been frustrated when ATC calls out another Cessna at 4 miles and I can't see it...or even at 2 miles. Seeing the relative size on the aid card really brings home the fact that I would be lucky to visually identify a small aircraft at 2 miles. I've been straining my eyes to see something that only chance would have me see...*
>
> *3) Being an professional ergonomist and a former USAF pilot and aircraft accident investigation specialist, I very much like the aircraft detection aid. Any visual that can help me spot another aircraft in the air is wonderful.*
>
> *4) Keep up the great work at FAA Safety it makes a vast difference to our air space safety.*
>
> *5) Thanks for developing the "Aid for Judging the Apparent Size of Aircraft" chart. A newly certified private pilot as of May, I will definitely put it to practical use.*

We have begun to adapt Olshausen's "sparse coding" analysis to develop a general model of detection in the aviation environment. This model incorporates differences in sparse coding for the target and background. We are continuing the development of training software to teach pilots how to recognize distance, relative direction, and altitude of targets. Data collection has continued for images in the aviation environment as proposed in Phase 1 of the project. We continue to evaluate and adapt vision detection models to the visibility issue. We are attempting to include parameters that account for search behavior and limitations need to be incorporated into these models. We have continued to develop software to test pilot target detection capabilities on various backgrounds composed of aviation images. We have started running detection experiments designed to evaluate the utility of synchronous and asynchronous strobe lights as aids to detection. We are continuing to develop experiments that will objectively measure performance under simulated flat light conditions.

All available information indicates the project is on track.

d) Electronic Primary and Multi-function Flight Displays for GA; Certification Criteria and Usability Assessments.

The first experiment planned for this project has been completed and the results were briefed at the AAR-100 Program Review (12/16/04) and to the Small Airplane

Directorate (12/18/04). Details of the findings appeared in earlier quarterly reports. A paper based upon the study was accepted for presentation at the International Symposium on Aviation Psychology to be held in Oklahoma City in April 2005 (D. Beringer, site chairman). An Office of Aviation Medicine Technical report and scientific proceedings article are currently in review. Follow-on evaluations that would be warranted in light of the reported results are being discussed with the sponsor.

Preparation work for the AFS-420 studies continued. CAMI personnel visited the software contractor's site early in the quarter, and the contractor subsequently delivered a software load for generating the attitude and pathway-guidance imagery on the monocular monochrome display. The software was being tested for acceptability, but some communications problems surfaced between the HMD computers and the AGARS. Debugging efforts are currently under way. The monocular display device was received and preliminary testing indicated that it was functional and could be interfaced easily with the HMD-generating computers.

All indications indicate that this project is on track to complete the milestones as planned.

e) Migration of HFACS database to a web-based interface

The web-based interface (http://www.hf.faa.gov/hfacs) was demonstrated at the FY 2004 Program Review. Work was completed on the pilot data entry portion of the HFACS application. One additional component that needs to be developed is the pilot data entry confirmation screen which will insure that the data the pilots selected for is visible to them before they commit it. Additional information has been received from the stakeholders about the layout and information required for the administrative section of the web site. Work should be progressing on that shortly.

CAMI will provide ATO-P HF a new QA'd database that will include all aviation accidents since 1990 over the next three quarters. The commercial database will be completed in the 2nd quarter followed by the remaining GA accidents 2001-present in the 2nd or 3rd quarter. Also included will be maintenance causal factors.

All available information indicates the project is on track.

f) Unmanned Aircraft Vehicle Mishap Analysis

The report entitled, "*A Summary of Unmanned Aircraft Accident/Incident Data: Human Factors Implications*" review is complete and the final editing process and is being prepared for publication as an Office of Aviation Medicine Technical Report. In addition, a submission for a chapter in a book on the human factors of unmanned aircraft entitled, "Human Factors Implications of RPV Accidents", for the future *Human Factors of Remotely Piloted Vehicles* volume of the *Advances in Human Performance and Cognitive Engineering Research* series has been accepted. The chapter will focus on the human factors of unmanned aircraft accidents. Final chapter submission is due in March 2005.

A summary of the human factors issues for UAV by personnel at the University of Illinois was reviewed and feedback provided to the study authors (McCarley & Wickens).

All indications indicate that this project is on track to complete the milestones as planned.

g) National Airspace Human Factors Integration Plan for Unmanned Aerial Vehicles

The final report is due to AVR on December 31st, 2004

h) Symbol Set Discriminability Metrics

Research Requirement Objective: The Federal Aviation Administration draft Advisory Circular (AC) (to be released in FY05), "Aircraft Surveillance Systems and Applications" identified a limited number of airborne and airport surface traffic symbols for a low-end traffic cockpit display. The AC specified the minimum symbol size to achieve satisfactory discriminability. Additional studies need to be conducted to evaluate other airborne and airport surface traffic symbols and how these symbols affect pilot discriminability on various types of traffic cockpit displays. Ideally, the Federal Aviation Administration needs a simple method to evaluate whether an applicant's proposed text and symbols on a given display. The applicant would retrieve a library of airborne and airport surface traffic symbols from the Federal Aviation Administration then run a vision discriminability model to assess a display's performance for those symbols. The output of the model would indicate whether the symbol has enough discriminability to be accepted by the Federal Aviation Administration certification.

Project Objective: modify the luminance image discrimination model to include color and extend a multiple image classification model to predict text or symbol discriminability. The model input parameters will include: (1) CIE Yxy images of the actual images computed from display characteristics (number of pixels, CIE values, gamma, spatial size, etc), and (2) 'ideal' text or symbols (obtained from a look-up-table of accepted AVR symbols). The model will be tested on text and symbol data and if successful it will allow the user to predict users' text or symbol discriminability for a given display using accepted AVR text and symbols.

Researcher's accomplishments to date:

The following work plan has been formulated.

1. Construct a model for image categorization in Matlab. The current image discrimination model has the following steps. Two images are converted to contrast. The two contrast images are filtered by a contrast sensitivity filter. The visible contrast images are reduced in contrast by a contrast gain masking function. The generalized distance between the images is converted to a number of threshold discrimination units (JNDs).

2. For our preliminary image categorization model we will perform the following steps to each image that is to be categorized. The image is converted to contrast. The contrast image is filtered by a contrast sensitivity filter. The visible contrast image is reduced in contrast by a contrast gain masking function. The minimum distance between all the translated versions of the visible masked contrast images and each of the category templates is computed. These minimum distances are then converted to a response probability distribution over the categories. There are many candidate rules for computing the templates, including filtered and

unfiltered examples of the category. Initially we plan to use unfiltered contrast examples, but since this issue has not been researched much, we plan to test multiple rules for generating the templates.

3. Test the model on the already available data.

4. Set up a symbol discrimination experiment with possible goals:
    - Evaluate other proposed symbols.
    - Include some background variation, or other desired variables.
    - Specifically test among alternative classification models.
    - Test the model(s) on the new data.

My plan is to try to complete these steps by the end of the summer and then begin trying to extend the model so that it has some size and rotation invariance as well as the translation invariance.

New start. Cost share with NASA Ames. All available information indicates the project is on track.

i) FITS - Proficiency Standards for Technically Advanced Aircraft

The objective of the project is to create a document for pilots and instructors, similar in spirit to an advisory circular (AC) or the FAA-H-8083 series of publications, that outlines proficiency standards for advanced avionics, resources and references to help students meet the standards, an operational or research basis for including each element in the standards, likely training required to meet the standards along with common student errors, both supported by in-flight observations of students learning to fly technically advanced aircraft.

New start. Cost share with NASA Ames. All available information indicates the project is on track.

j) FITS - Enhanced Decision Making (EDM)

This quarter has been primarily devoted to planning for this project. I have been refining the technique to be used for the cognitive task analysis. This analysis will provide information about usage of the advanced displays in the technically advanced aircraft and if designed properly will provide guidance about how to train pilots in these aircraft. In addition, a furloughed United Airlines (UAL) pilot and CFI was hired onto the project and to begin systematic analysis of ASRS reports.

New start. Cost share with NASA Ames. All available information indicates the project is on track.

k) Unmanned Aircraft Operator Qualification and Training Requirements

The "Role of Human Factors in Unmanned Aerial Vehicles" contract announcement was canceled. Work will be completed through an alternative method.

The final report will be due to AVR on December 31st, 2005

l) General Aviation Private Pilot Survey / Initial Certified Flight Instructor – Airplane Survey/ Designated Pilot Examiner Program Assessment

Dr. Hackworth, Crystal Cruz, and Janine King responded to comments provided by the Bureau of Transportation Statistics (BTS) on the ASEL GA survey. The BTS review is a preliminary step prior to OMB review and approval. The survey and OMB materials were updated and resubmitted to OMB. The required Federal Register notice of 60 days was completed Dec. 23rd. Dr. Hackworth contacted Judy Street to remind her to submit the OMB materials.

Drs. Hackworth and Shappell, Crystal Cruz, L. Nuckolls, Roger Moore, and Bruce Rengstorf held a telcon to discuss the ASEL GA Survey report distribution method.

The DPE draft survey was submitted to members of the Pilot Examiner System Safety New Program team for their review and comment. The goal is to have the DPE survey completed by Feb. 1, 2005.

All indications indicate that this project is on track to complete the milestones as planned.

m) A New Approach to Aviation Accident/Incident Prevention/Mitigation

Historically, accident and incident interventions have been generated by the NTSB in the form of recommendations or have come from experts in the government (FAA, NASA, etc.), military, or other aviation organizations. As a result, they tend to focus on the prevention of specific types of accidents like those related to spatial disorientation or controlled flight into terrain, rather than specific types of human error per se.

What is needed is a systematic approach to generating intervention/prevention strategies that can tie into the HFACS framework in use with civilian aviation accident and incident data. One such approach has been developed by the collaborative efforts of the University of Illinois (Dr. Douglas Wiegmann) and the Civil Aerospace Medical Institute (Dr. Scott Shappell). Referred to as the Human Factors Intervention Matrix (HFIX), it pits the causal categories associated with HFACS (e.g., skill-based errors, decision errors, adverse mental states, etc.) against five approaches to accident/incident intervention:

- Technology/Engineering
- Human/Crew
- Organizational/Administrative
- Task/Mission
- Operational/Physical Environment.

As part of FAA's efforts aimed at validating HFIX and ensuring its reliability for use with civilian aviation accidents/incidents, the University of Illinois and CAMI scientists are independently assessing NTSB recommendations and GA JSAT/JSIT interventions with the tool. This assessment will provide several important data points. First, it will

ensure that two organizations (the University of Illinois and CAMI) can independently use HFIX and derive the same results thereby providing initial reliability measures. Second, it will provide input to FAA sponsors as to whether or not existing recommendations and interventions target areas of aircrew error (i.e., skill-based errors, decision errors, etc.) known to be responsible for GA accidents. Finally, it will identify areas in which the current version of HFIX can be improved/modified.

Toward these ends, both NTSB and FAA JSAT/JSIT data is currently being classified by subject-matter experts at both institutions. It is anticipated that the data collection phase will conclude in the 2nd quarter of FY05 and the data analysis phase will commence in the 3rd quarter of FY05 with a report to follow shortly thereafter.

This effort is identified within the AVR Business Plan on page 17 under Core Business Measure: GA Fatal Accidents, Core Activity: Research and Development – GA, Activity Targets: Complete development and validation of the Human Factors Interventions Matrix (HFIX) for use by AVR and submit report to sponsor in September 2005.

All available information indicates that this project is on track.

William K. Krebs